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MORE ON A MODEL CURRICULUM FOR MODELING AND SIMULATION

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ABSTRACT

At WSC 00, one of the authors (Crosbie) suggested that the development and publication of a Model Curriculum for MS programs in Modeling and Simulation would facilitate the development of such programs. This paper presents a first draft of a Model Curriculum developed by a small group at the McLeod Institute of Simulation Sciences at California State University, Chico. The aim of the draft is to stimulate further discussion in the M&S community with the goal of arriving at a generally acceptable outline that can serve as a guideline for new programs.

1 INTRODUCTION

As the demand for Modeling and Simulation (M&S) professionals continues to increase, much attention has been focused recently on what constitutes a proper educational preparation for a career in M&S. At WSC 00 one of the authors (Crosbie 2000) proposed the development of a Model Curriculum for a MS degree in M&S to assist schools planning new programs in the field. This suggestion was based on experience in the 1980s of developing a new BS program in Computer Engineering, a task that was greatly facilitated by the availability of a model curriculum for Computer Science and Engineering (CSE) published by IEEE-CS and ACM.

The task of defining a curriculum for a MS degree in M&S is particularly difficult, partly because M&S is not normally seen as a discipline in its own right in most universities. It is usually regarded as a fragmented subject with components in a range of disciplines including, but not necessarily restricted to, computer science, various engineering disciplines, mathematics, business, natural and physical sciences and the social sciences. Furthermore, the range of applications of M&S is so wide that almost any university department could possibly offer a course on M&S applied to it's particular discipline. This results in a situation in which course offerings relevant to M&S, and that might be included in an M&S degree program, tend to be scattered throughout the university, with no central responsibility for M&S as a discipline.

This was one of the reasons for the development of the McLeod Institute for Simulation Sciences (MISS), a program of the Society for Modeling and Simulation International (SCS), first at California State University, Chico and subsequently at over 20 campuses throughout the world. These interdisciplinary centers, named in honor of John McLeod P.E., SCS founder, act as a focus for faculty, students, research and educational programs in M&S on their respective campuses, and provide an international forum for collaboration in M&S related activities.

One way of handling this fragmented array of individual courses and departments is the interdisciplinary degree. This is the mechanism currently used at CSU, Chico, which offers a flexible MS in Interdisciplinary Studies (MSIS) that allows a student, with faculty support, to devise a program of study from the course offerings of multiple departments that can address specific academic goals not provided for in the regular graduate programs of the university. The MSIS in Simulation Science at Chico requires 9 semester units (3 courses) of M&S fundamentals covering methodology and tools and techniques, and a project of at least 3 units on a topic related to M&S. The student selects the remaining courses without specific restrictions as to department or discipline as long as they conform to the student's academic goals and receive faculty approval.

Another approach is for universities to combine forces, and CSU, Chico is also pursuing this route in a consortium of 3 US and 3 European universities that are together planning an international graduate program in M&S making use of on-line courses, faculty exchanges and student exchanges to broaden the base of M&S courses available to students from a particular campus. At the time of writing, two of the European partners, the University of Hamburg, Germany and the Technical University of Vienna, Austria are sharing

on-line courses, and a faculty member from Hamburg is teaching a summer session course at CSU, Chico.

Whatever the administrative basis for a graduate program in M&S, it can only be helped by the availability of a set of generally agreed guidelines on the structure and composition of the degree. Having said this, it is important that the guidelines should be capable of flexible interpretation, avoiding a "*one size fits all*" approach. This was achieved in the CSE guidelines by specifying course content in the form of subject areas rather than complete courses. This allows the program developers to mix and match different subject areas to produce individual courses that best fit the needs and resources of a particular institution. As long as the mix of courses provides for all of the subject areas that are required, and adequately provides for those that are optional, the program conforms to the guidelines. It is important to recognize that we are not advocating that the guidelines should be treated as accreditation requirements. Quoting from the WSC 2000 paper:

> *"An important point to note is that a model program is not the same as a set of accreditation requirements. Rather than mandating that certain features must be present if a program is to be accredited, a model program is a set of guidelines that are intended to assist program designers in developing programs. The model program should also be defined in terms of topic lists that recommend both required and optional topics rather than complete courses. The aggregation of topics into individual courses should be the responsibility of the program designer. This is particularly important if the model program is to have international validity bearing in mind the different program structures and course durations that are common in different countries."*

This is the approach adopted here. The effort is still at an early stage, and the following draft should be regarded as an initial effort by a small group from a single institution with the intention of stimulating discussion. It is being circulated to the campuses in the international consortium referred to earlier for their input, and others are invited to submit their comments by e-mail to: <rcrosbie@csuchico.edu>

2 2 COMPONENTS OF THE M&S DEGREE

The WSC 00 paper recommended that the M&S degree contain the following four major components: *Fundamentals of M&S; Simulation Tools and Techniques; Applications of M&S; and M&S Project.* The next section suggests more detailed content for each of these components.

This initial draft assumes an MS program of 30 semester units (equivalent to approximately 10 semester courses). Students entering the program are assumed to have an adequate background in basic topics in computer science, mathematics, physics and their primary BS discipline.

Although the guidelines do not prescribe the number of units to be allocated to each of the above areas, it is recommended that at least two courses (6 semester units) be allocated to each of the first three areas and 3 semester units to the project. This accounts for 21 units and leaves 9 units (3 courses) at the discretion of the program or for use as electives.

3 DETAILS OF PROGRAM CONTENT

We define four Subject Areas (SA) as follows:

1. SA1: Fundamentals of Modeling and Simulation.
2. SA2: Tools and Techniques for Modeling and Simulation.
3. SA3: Applications of Modeling and Simulation.
4. SA4: Modeling and Simulation Project.

Each subject area is divided into a number of sub-areas. Each sub-area can be regarded as the basis for a single course, part of a course, or even more than one course. Topics can be taken from different sub-areas and combined to form a course and the topics in a given sub-area may be distributed between different courses. The aim is to produce a general topology for the material that should map onto the course content of the actual degree program. Because of the wide variety of simulation applications it is likely that individual programs will emphasize different aspects of the material, and may find it necessary to include additional material that is not included here.

SA1: *Fundamentals of Modeling and Simulation*

- 1.1 Basic methodology.
- 1.2 The M&S process, V&V.
- 1.3 Modeling formalisms, time representation in dynamic models.
- 1.4 Discrete models: DEVS, queuing theory, random number generation, statistical analysis of model outputs.
- 1.5 Continuous models: differential equations, difference equations, numerical solution of differential equations.
- 1.6 Data issues: getting reliable data, model validity, initializing a model, parameter sensitivity, optimization, errors in simulation.

SA2: *Tools and Techniques for Modeling and Simulation*

- 2.1 Programming approaches for M&S. HLLs, general discrete and continuous languages and packages, application-specific languages and packages.

2.2 Specific examples of discrete M&S software. Specific examples of continuous M&S software.
2.3 Real-time simulation for human, hardware and software in the loop applications.
2.4 Visualization, animation, data representation for M&S.

SA3: *Applications of Modeling and Simulation*

3.1 At least one in depth study of the use of discrete modeling and simulation in a specific application area.
3.2 At least one in depth study of the use of continuous modeling and simulation in a specific application area.
3.3 At least one in depth study of the use of real-time modeling and simulation in a specific application area.

SA4: *Modeling and Simulation Project*

4.1 We make no claim that these subject area definitions are complete. They are merely offered as a starting point for discussion and elaboration. We would welcome all comments, both positive and negative, including suggestions for alternate ways of arriving at a set of guidelines that are both sufficiently prescriptive to provide positive guidance to program developers and sufficiently flexible to avoid undue restrictions on the development of innovative programs in an area that has so many facets and multi-disciplinary aspects.

4 CONCLUSIONS

A "strawman" version of a model curriculum for a graduate degree in Modeling and Simulation is proposed. We hope that this can be used as a basis for wide-ranging discussions that will lead to a published version sponsored by interested professional bodies such as ACM, SCS and IEEE-CS.

REFERENCE

Crosbie, R. E. 2000. A Model Curriculum in Modeling and Simulation: Do We Need It? Can We Do It? In *Proceedings of the 2000 Winter Simulation Conference*, Piscataway, New Jersey:Institute of Electrical and Electronics Engineers. Available on-line via <http://www.informs-cs.org/wsc00papers/abstracts/ed.htm#crosbier-1i> [Accessed May 10, 2001]

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